WHAT IS CLAIMED IS:

1. An optical demultiplexer for separating input wavelength-multiplexed light of first and second wavelengths, comprising:

a multi-mode propagation portion allowing multi-mode propagation of light of the first and second wavelengths, and separating powers of the light of first and second wavelengths by causing internal mode interference;

an input portion for inputting light to the multi-mode propagation portion from such an input position as to cause separation of the powers of light in the multi-mode propagation portion; and

first and second output portions for outputting the light of first and second wavelengths from the multi-mode propagation portion via such positions on an output end face as to cause separation of the powers of the light of first and second wavelengths and maximize an extinction ratio indicating the size of the power of light of a desired wavelength with respect to the power of light of a wavelength to be cut off.

2. The optical demultiplexer according to claim 1, wherein when a value of the extinction ratio corresponds to ten times the natural logarithm of the quotient obtained by dividing the power of light of the desired wavelength by the power of light

of the wavelength to be cut off, the extinction ratio is equal to or more than 30dB at a position where the extinction ratio is maximized.

3. The optical demultiplexer according to claim 1, wherein a refractive index of the multi-mode propagation portion is less than or equal to 2.0.

4. The optical demultiplexer according to claim 1, wherein the width of the multi-mode propagation portion is equal to or more than 15 μm.

5. The optical demultiplexer according to claim 1,

wherein the first output portion is located in a position where the power of light of the second wavelength is minimized, and

wherein the second output portion is located in a position where the power of light of the first wavelength is minimized.

6. The optical demultiplexer according to claim 1, wherein in the case where a phase difference between zero- and first-order modes of the first wavelength is θ_1 and a phase difference between zero- and first-order modes of the second wavelength is θ_2, the multi-mode propagation portion has such an

optical path length in a propagation direction as to cause a difference between θ_1 and θ_2 to be in the range of $m\pi\pm\pi/2$, where m is a natural integer.

7. The optical demultiplexer according to claim 6, wherein the multi-mode propagation portion has such an optical path length in the propagation direction as to cause at least one of the powers of the light of first and second wavelengths to be minimized or maximized at an output end of each of the first and second wavelengths.

8. The optical demultiplexer according to claim 7, wherein the multi-mode propagation portion has such an optical path length in the propagation direction as to cause the difference between θ_1 and θ_2 to become an integral multiple of π.

9. The optical demultiplexer according to claim 8, wherein the multi-mode propagation portion has such an optical path length in the propagation direction as to cause the powers of the light of first and second wavelengths to become minimum or maximum values inverted with respect to each other at the output end of each of the first and second wavelengths.

10. The optical demultiplexer according to claim 6, wherein the multi-mode propagation portion has such an optical

path length in the propagation direction as to cause the extinction ratio at the output end of each of the first and second wavelengths to become equal to or more than 30 dB.

11. The optical demultiplexer according to claim 6, wherein the multi-mode propagation portion has such an optical path length in the propagation direction as to cause the difference between θ_1 and θ_2 to become an integral multiple of π.

12. The optical demultiplexer according to claim 6,

wherein the multi-mode propagation portion is formed by one multi-mode waveguide,

wherein the center line of the multi-mode waveguide corresponds to an optical axis of the multi-mode propagation portion, and

wherein the input position is offset from the optical axis.

13. The optical demultiplexer according to claim 6,

wherein the multi-mode propagation portion is formed by two single-mode waveguides,

wherein an axis of symmetry between the two multi-mode waveguides corresponds to an optical axis of the multi-mode propagation portion, and

wherein the input position is an input end of either

of the two single-mode waveguides.

14. The optical demultiplexer according to claim 1, wherein the multi-mode propagation portion includes:

a first optical path length portion having an optical path length in a propagation direction such that, in the case where a phase difference between zero- and first-order modes of the first wavelength is θ_1 and a phase difference between zero- and first-order modes of the second wavelength is θ_2, a difference between θ_1 and θ_2 is in the range of $m\pi\pm\pi/2$, where m is a natural integer; and

a second optical path length portion having an optical path length in the propagation direction such that the difference between θ_1 and θ_2 is in the range of $m\pi\pm\pi/2$,

wherein light of the first wavelength is outputted from the first optical path length portion,

wherein light of the second wavelength is outputted from the second optical path length portion, and

wherein the first and second optical path length portions have different optical path lengths.

15. The optical demultiplexer according to claim 14, wherein the first optical path length portion has such an optical path length in the propagation direction as to cause the difference between θ_1 and θ_2 to become an integral multiple

of π, and

wherein the second optical path length portion has such an optical path length in the propagation direction as to cause the difference between θ_1 and θ_2 to become an integral multiple of π.

16. The optical demultiplexer according to claim 14,

wherein the multi-mode propagation portion is formed by one multi-mode waveguide,

wherein the center line of the multi-mode waveguide corresponds to an optical axis of the multi-mode propagation portion, and

wherein the input position is offset from the optical axis.

17. The optical demultiplexer according to claim 14,

wherein the multi-mode propagation portion is formed by two single-mode waveguides having different lengths, and

wherein an axis of symmetry between the two multi-mode waveguides corresponds to an optical axis of the multi-mode propagation portion.

18. The optical demultiplexer according to claim 1,

wherein the multi-mode propagation portion has an optical path length in a propagation direction such that, in the

case where a phase difference between zero- and first-order modes of the first wavelength is θ_1 and a phase difference between zero- and first-order modes of the second wavelength is θ_2, a difference between θ_1 and θ_2 is in the range of $m\pi\pm\pi/2$, where m is a natural integer, and

wherein the multi-mode propagation portion includes:

a first multi-mode region capable of transmitting therethrough only multi-mode light of a shorter one of the first and second wavelengths; and

a second multi-mode region capable of transmitting therethrough multi-mode light of the first and second wavelengths, the second multi-mode region being present downstream in a traveling direction of light from the first multi-mode region.

19. The optical demultiplexer according to claim 18, wherein the multi-mode propagation portion has such an optical path length in the propagation direction as to cause the difference between θ_1 and θ_2 to become an integral multiple of π.

20. The optical demultiplexer according to claim 18,

wherein the multi-mode propagation portion is formed by one multi-mode waveguide, and

wherein the first and second multi-mode regions are formed by cutting out a portion having a rectangular solid-shape from the input side of the multi-mode waveguide, such that the

first multi-mode region becomes partially narrower than the second multi-mode region.

21. The optical demultiplexer according to claim 20, wherein the input position is offset from the optical axes of the first and second multi-mode regions.

22. The optical demultiplexer according to claim 18,

wherein the first multi-mode region is formed by two former-stage single-mode waveguides used as a former-stage multi-mode region,

wherein the second multi-mode region is formed by two latter-stage single-mode waveguides used as a latter-stage multi-mode region, and

wherein a space between the former-stage single-mode waveguides is narrower than a space between the latter-stage single-mode waveguides.

23. The optical demultiplexer according to claim 18, wherein the centers of the axes of the first and second multi-mode regions are offset from each other.

24. The optical demultiplexer according to claim 1,

wherein in the case where a phase difference between zero- and first-order modes of the first wavelength is θ_1 and a

phase difference between zero- and first-order modes of the second wavelength is θ_2, the multi-mode propagation portion has such an optical path length in a propagation direction as to cause a difference between θ_1 and θ_2 to be in the range of $m\pi\pm\pi/2$, where m is a natural integer, and

wherein the width of the multi-mode propagation portion varies along a direction of an optical axis of the optical demultiplexer.

25. The optical demultiplexer according to claim 24, wherein the multi-mode propagation portion has such an optical path length in the propagation direction as to cause the difference between θ_1 and θ_2 to become an integral multiple of π.

26. The optical demultiplexer according to claim 24,

wherein the multi-mode propagation portion is formed by one multi-mode waveguide, and

wherein the center line of the multi-mode waveguide corresponds to an optical axis of the multi-mode propagation portion.

27. The optical demultiplexer according to claim 24,

wherein the multi-mode propagation portion is formed by two single-mode waveguides, and

wherein an axis of symmetry between the two multi-mode

waveguides corresponds to an optical axis of the multi-mode propagation portion.

28. The optical demultiplexer according to claim 1, further comprising:

a first latter-stage multi-mode propagation portion provided at an output end of the first output portion, the first latter-stage multi-mode propagation portion having the same characteristic as that of the multi-mode propagation portion;

a second latter-stage multi-mode propagation portion provided at an output end of the second output portion, the second latter-stage multi-mode propagation portion having the same characteristic as that of the multi-mode propagation portion;

a first latter-stage output portion for outputting light of the first wavelength to be separated by the first latter-stage multi-mode propagation portion; and

a second latter-stage output portion for outputting light of the second wavelength to be separated by the second latter-stage multi-mode propagation portion.

29. The optical demultiplexer according to claim 1, further comprising an external electric field control section for applying an external electric field to the multi-mode propagation portion, wherein the multi-mode propagation portion is formed of an electro-optic material.

30. The optical demultiplexer according to claim 29, wherein the external electric field control section includes:

a pair of electrodes provided on a surface of the multi-mode propagation portion; and

an external voltage control section for controlling a voltage between the pair of electrodes.

31. The optical demultiplexer according to claim 1, further comprising an external temperature control section for controlling the temperature of the multi-mode propagation portion, wherein the multi-mode propagation portion is formed of a thermo-optic material having a temperature dependence.

32. The optical demultiplexer according to claim 31, wherein the external temperature control section includes:

a heat conducting member provided on a surface of the multi-mode propagation portion; and

a temperature control member for controlling the temperature of the multi-mode propagation portion by heating and/or cooling the heat conducting portion.

33. The optical demultiplexer according to claim 31, wherein the external temperature control section includes:

a Peltier device provided on a surface of the multi-mode

propagation portion; and

a temperature control member for controlling the temperature of the multi-mode propagation portion by applying a current to the Peltier device.

34. The optical demultiplexer according to claim 1,

wherein the input portion is a waveguide optically coupled to the input side of the multi-mode propagation portion, and

wherein each of the first and second output portions is a waveguide optically coupled to the output side of the multi-mode propagation portion.

35. An optical device for transmitting/receiving light of first and second wavelengths, the optical device comprising:

a multi-mode propagation portion allowing multi-mode propagation of light of the first and second wavelengths and separating powers of the light of first and second wavelengths by causing internal mode interference;

an input portion for inputting light to the multi-mode propagation portion from such an input position as to cause separation of the powers of light in the multi-mode propagation portion;

first and second output portions for outputting the light of first and second wavelengths from the multi-mode propagation

portion via such positions on an output end face as to cause separation of the powers of the light of first and second wavelengths and maximize an extinction ratio indicating the size of the power of light of a desired wavelength with respect to the power of light of a wavelength to be cut off;

a first optical element for receiving and/or emitting light of the first wavelength, the first optical element being provided at an output end of the first output portion; and

a second optical element for receiving and/or emitting light of the second wavelength, the second optical element being provided at an output end of the second output portion.

36. The optical device according to claim 35, wherein the second optical element includes:

a light emitting portion for emitting light of the second wavelength; and

a light receiving portion for receiving light of the second wavelength.

37. An optical demultiplexer for separating input wavelength-multiplexed light of n types of different wavelengths, where n is a natural integer, the optical demultiplexer comprising:

a multi-mode propagation portion allowing multi-mode propagation of the input wavelength-multiplexed light of n types of different wavelengths and separating powers of the light of

n types of different wavelengths by causing internal mode interference;

an input portion for inputting light to the multi-mode propagation portion from such an input position as to cause separation of the powers of light in the multi-mode propagation portion; and

n output portions for outputting the light of n types of different wavelengths from the multi-mode propagation portion via such positions on an output end face as to cause separation of the powers of the light of n types of different wavelengths and maximize an extinction ratio indicating the size of the power of light of a desired wavelength with respect to the power of light of a wavelength to be cut off.

38. The optical demultiplexer according to claim 37, wherein in the case where i=0,1,...,n and k=1, 2,...,n-1, when a phase difference between i'th- and i+1'th-order modes of a k'th wavelength λ_k is θ_k and a phase difference between i'th- and i+1'th-order modes of a k+1'th wavelength λ_{k+1} is θ_{k+1}, the multi-mode propagation portion has such an optical path length in a propagation direction as to cause a difference between θ_k and θ_{k+1} as to be in the range of $m\pi\pm\pi/2$, where m is a natural integer.

39. The optical demultiplexer according to claim 38, wherein the multi-mode propagation portion is formed

by one multi-mode waveguide,

wherein the center line of the multi-mode waveguide corresponds to an optical axis of the multi-mode propagation portion, and

wherein the input position is offset from the optical axis.

40. The optical demultiplexer according to claim 38, wherein the multi-mode propagation portion is formed by n single-mode waveguides, and

wherein an axis of symmetry between outermost single-mode waveguides among the n single-mode waveguides corresponds to an optical axis of the multi-mode propagation portion.

41. The optical demultiplexer according to claim 40, wherein the n single-mode waveguides are equally spaced.

42. The optical demultiplexer according to claim 37, wherein the n types of different wavelengths are equally spaced.

43. An optical multi-/demultiplexer for combining/separating light of first and second wavelengths, the optical multi-/demultiplexer comprising:

a multi-mode propagation portion allowing multi-mode

propagation of the light of first and second wavelengths and separating powers of the light of first and second wavelengths by causing internal mode interference;

an input portion for inputting light to the multi-mode propagation portion from such an input position as to cause separation of the powers of light in the multi-mode propagation portion; and

first and second output portions for outputting the light of first and second wavelengths from the multi-mode propagation portion via such positions on an output end face as to cause separation of the powers of the light of first and second and maximize an extinction ratio indicating the size of the power of light of a desired wavelength with respect to the power of light of a wavelength to be cut off.

44. An optical multi-/demultiplexer for combining/separating light of n types of different wavelengths, where n is a natural integer, the optical multi-/demultiplexer comprising:

a multi-mode propagation portion allowing multi-mode propagation of the light of n types of different wavelengths and separating powers of the light of n types of different wavelengths by causing internal mode interference;

an input portion for inputting light to the multi-mode propagation portion from such an input position as to cause

separation of the powers of light in the multi-mode propagation portion; and

n output portions for outputting the light of n types of different wavelengths from the multi-mode propagation portion via such positions on an output end face as to cause separation of the powers of the light of n types of different wavelengths and maximize an extinction ratio indicating the size of the power of light of a desired wavelength with respect to the power of light of a wavelength to be cut off.

45. An optical device for adjusting wavelength-multiplexed light of n types of wavelengths, where n is a natural integer, the optical device comprising:

a demultiplexing section for separating the light of n types of wavelengths;

a multiplexing section for combining the light of n types of wavelengths; and

n adjusting sections for adjusting light of the n types of wavelengths separated by the demultiplexing section and inputting the light of the n types of wavelengths to the multiplexing section,

wherein the demultiplexing section includes a demultiplexer multi-mode propagation portion allowing multi-mode propagation of the light of n types of wavelengths and separating powers of the light of n types of wavelengths by causing internal

mode interference,

wherein the multiplexing section includes a multiplexer multi-mode propagation portion allowing multi-mode propagation of the light of n types of wavelengths and combining powers of light of the n types of wavelengths by causing internal mode interference, and

wherein in the case where $i=0, 1, \ldots, n$ and $k=1, 2, \ldots, n-1$, when a phase difference between i'th- and i+1'th-order modes of a k'th wavelength λ_k is θ_k and a phase difference between i'th- and i+1'th-order modes of a k+1'th wavelength λ_{k+1} is θ_{k+1}, each of the demultiplexer and multiplexer multi-mode propagation portions has such an optical path length in a propagation direction as to cause a difference between θ_k and θ_{k+1} to be in the range of $m\pi \pm \pi/2$, where m is a natural integer.

46. The optical device according to claim 45, wherein each of the n adjusting sections adjusts at least one of a gain, a phase, and a polarized status for each wavelength.

47. The optical device according to claim 45, further comprising an external control section, wherein the external control section is able to communicate with each of the n adjusting sections so as to dynamically adjust at least one of a gain, a phase, and a polarized status for each wavelength.

48. The optical device according to claim 45, further comprising:

an external control section; and

a monitor section for monitoring the output of the multiplexer multi-mode propagation portion,

wherein the external control section is able to communicate with each of the n adjusting sections and the monitor section and to feed back an output status of the multiplexer multi-mode propagation portion so as to dynamically adjust at least one of a gain, a phase, and a polarized status for each wavelength.

49. An optical device having an add/drop function of extracting one of two wavelengths multiplexed in light and recombining the two wavelengths, the optical device comprising:

a demultiplexer for separating light of the two wavelengths;

a multiplexer for combining light of the two wavelengths;

a relay waveguide for relaying light of a first wavelength in wavelength-multiplexed light to the multiplexer, the relay waveguide being connected to the output side of the demultiplexer;

a drop waveguide for guiding light of a second waveguide in the wavelength-multiplexed light to the outside of the demultiplexer, the drop waveguide being connected to the output side of the demultiplexer; and

an add waveguide for guiding the light of the second wavelength back into the demultiplexer and relaying the light to the multiplexer,

wherein the demultiplexer includes a demultiplexer multi-mode propagation portion allowing multi-mode propagation of light of the first and second wavelengths and separating powers of the light of the first and second wavelengths by causing internal mode interference,

wherein the multiplexer includes a multiplexer multi-mode propagation portion allowing multi-mode propagation of the light of the first and second wavelengths and combining the powers of the light of the first and second wavelengths by causing internal mode interference, and

wherein in the case where a phase difference between zero- and first-order modes of the first wavelength is θ_1 and a phase difference between zero- and first-order modes of the second wavelength is θ_2, each of the demultiplexer and multiplexer multi-mode propagation portions has such an optical path length in a propagation direction as to cause a difference between θ_1 and θ_2 to be in the range of $m\pi \pm \pi/2$, where m is a natural integer.

50. An optical demultiplexer for separating, into two groups of wavelengths, input wavelength-multiplexed light of 2n types of different wavelengths $\lambda_1, \ldots, \lambda_{2n}$, where n is a natural integer, the optical demultiplexer comprising:

a multi-mode propagation portion allowing multi-mode propagation of light of the 2n types of different wavelengths in the input wavelength-multiplexed light and separating powers of light of the two groups of wavelengths by causing internal mode interference;

an input portion for inputting light to the multi-mode propagation portion from such an input position as to cause separation of powers of light in the multi-mode propagation portion; and

two output portions for outputting the light of the two groups of wavelengths from such positions as to cause separation of the powers of the light of the two groups of wavelengths,

wherein the two groups of wavelengths consist of the group of odd-numbered multiplexed wavelengths and the group of even-numbered multiplexed wavelengths.

51. The optical demultiplexer according to claim 50, wherein in the case where k=1, 2, ..., n-1, when a phase difference between zero- and first-order modes of a 2k-1'th wavelength λ_{2k-1} is θ_{2k-1} and a phase difference between zero- and first-order modes of a 2k'th wavelength λ_{2k} is θ_{2k}, the multi-mode propagation portion has such an optical path length in a propagation direction as to cause a difference between θ_{2k-1} and θ_{2k} to be in the range of $m\pi \pm \pi/2$, where m is a natural integer.

52. The optical demultiplexer according to claim 51,

wherein the multi-mode propagation portion is formed by one multi-mode waveguide,

wherein the center line of the multi-mode waveguide corresponds to an optical axis of the multi-mode propagation portion, and

wherein the input position is offset from the optical axis.

53. The optical demultiplexer according to claim 51,

wherein the multi-mode propagation portion is formed by two single-mode waveguides having different lengths, and

wherein an axis of symmetry between the two single-mode waveguides corresponds to an optical axis of the multi-mode propagation portion.

54. The optical demultiplexer according to claim 50,

wherein in the case where k=1, 2,...,n-1, when a phase difference between zero- and first-order modes of a 2k-1'th wavelength λ_{2k-1} is θ_{2k-1} and a phase difference between zero- and first-order modes of a 2k'th wavelength λ_{2k} is θ_{2k}, the multi-mode propagation portion includes:

a first optical path length portion having such an optical path length in a propagation direction as to cause a difference between θ_{2k-1} and θ_{2k} to be in the range of $m\pi\pm\pi/2$, where

m is a natural integer; and

a second optical path length portion having such an optical path length in the propagation direction as to a difference between θ_{2k-1} and θ_{2k} to be in the range of $m\pi \pm \pi/2$,

wherein the group of the odd-numbered multiplexed wavelengths is outputted from the first optical path length portion,

wherein the group of the even-numbered multiplexed wavelengths is outputted from the second optical path length portion, and

wherein the first and second optical path length portions have different optical path lengths.

55. The optical demultiplexer according to claim 54,

wherein the multi-mode propagation portion is formed by one multi-mode waveguide,

wherein the center line of the multi-mode waveguide corresponds to an optical axis of the multi-mode propagation portion, and

wherein the input position is offset from the optical axis.

56. The optical demultiplexer according to claim 54,

wherein the multi-mode propagation portion is formed by two single-mode waveguides having different lengths, and

wherein an axis of symmetry between the two single-mode waveguides corresponds to an optical axis of the multi-mode propagation portion.

57. The optical demultiplexer according to claim 50, wherein the 2n types of wavelengths are equally spaced.

58. The optical demultiplexer according to claim 50, wherein a refractive index of the multi-mode propagation portion is in linear relationship with a wavelength in at least n types of wavelength ranges.

59. The optical demultiplexer according to claim 50,

wherein n is a number which satisfies n=4k, where k is a natural integer, and

wherein the optical demultiplexer further comprises:

a first latter-stage multi-mode propagation portion optically connected to an output end of the output portion for guiding the group of odd-numbered multiplexed wavelengths and having the same characteristic as that of the multi-mode propagation portion;

a second latter-stage multi-mode propagation portion optically connected to the output end of the output portion for guiding the group of even-numbered multiplexed wavelengths and having the same characteristic as that of the multi-mode

propagation portion;

a first latter-stage output portion for outputting the group of 4k-3'th wavelengths separated by the first latter-stage multi-mode propagation portion;

a second latter-stage output portion for outputting the group of 4k-1'th wavelengths separated by the first latter-stage multi-mode propagation portion;

a third latter-stage output portion for outputting the group of 4k-2'th wavelengths separated by the second latter-stage multi-mode propagation portion; and

a fourth latter-stage output portion for outputting the group of 4k'th wavelengths separated by the second latter-stage multi-mode propagation portion.

60. An optical demultiplexer for separating input wavelength-multiplexed light of first and second wavelengths, the optical demultiplexer comprising:

a first multi-mode propagation portion for separating powers of light of third and fourth wavelengths by causing internal mode interference, the third wavelength being offset from the first wavelength by a prescribed wavelength, the fourth wavelength being offset from the second wavelength by a prescribed wavelength,

an input portion for inputting light to the first multi-mode propagation portion from such an input position as to cause separation of powers of light in the first multi-mode

propagation portion;

a first output portion provided to an output end face of the first multi-mode propagation portion in such a position as to cause separation of the powers of light of the third and fourth wavelengths and maximize an extinction ratio indicating the size of the power of light of the fourth wavelength with respect to the power of light of the third wavelength;

a second output portion provided to the output end face of the first multi-mode propagation portion in such a position as to cause separation of the powers of light of the third and fourth wavelengths and maximize the extinction ratio indicating the size of the power of light of the fourth wavelength with respect to the power of light of the third wavelength;

second and third multi-mode propagation portions each separating powers of light of fifth and sixth wavelengths by causing internal mode interference, the fifth wavelength being offset from the first wavelength by a prescribed wavelength in a direction opposite to a direction of the offset of the third wavelength, the sixth wavelength being offset from the second wavelength by a prescribed wavelength in a direction opposite to a direction of the offset of the fourth wavelength;

a third output portion provided to an output end face of the second multi-mode propagation portion in such a position as to cause separation of powers of light of the fifth and sixth wavelengths and maximize the extinction ratio indicating the size

of the power of light of the sixth wavelength with respect to the power of light of the fifth wavelength; and

a fourth output portion provided to an output end face of the third multi-mode propagation portion in such a position as to cause separation of the powers of light of the fifth and sixth wavelengths and maximize the extinction ratio indicating the size of the power of light of the sixth wavelength with respect to the power of light of the fifth wavelength.

61. The optical demultiplexer according to claim 60,

wherein the third and fifth wavelengths are symmetric with respect to the first wavelength, and

wherein the forth and sixth wavelengths are symmetric with respect to the second wavelength.